**UNIT III Special theory of relativity**

**Special theory of relativity:** Inertial and non-inertial frames, Galilean transformation, Michelson-Morley experiment, Einstein postulates of special theory of relativity, Lorentz transformation equation, length contraction, time dilation, variation mass with velocity, Mass-energy relation.

Q. 7 Derive expression of variation of mass phenomena.

**Variation of Mass:**

To investigate what happens to the mass of an object as its speed increases, we consider an elastic collision between two particles **A** and **B**. Before the collision, particle **A** had been at rest in frame **S** and particle **B** in **S’.** Then, at the same instant, **A** was thrown in the **+y** direction at the speed **VA** while **B** was thrown in the **–y** direction at the speed **VB’** where

**……… (1)**

Hence the behavior of A as seen from **S** is exactly the same as the behavior of B as seen from in S’.

When the two particle collide, **A** rebounds in the –y direction at the speed **VA** while **B** rebounds in the +y direction at the speed **VB’.** As shown in **fig.1** theparticles collide at distance **Y=1/2y. T**he round- trip time **T0** for **A** as measured in frame **S** is therefore

**……… (2)**

And it is the same for **B** in **S’**

**……… (3)**

If linear momentum is conserved in the **S frame**, it must be true that

**……… (4)**

In **S** the speed **VB** is found from

**……… (5)**

Where **T** is the time required for **B** to make its round-trip as measured in **S**. In **S’** however, **B’s** trip requires the time **T0** where

**……… (6)**

Therefore **VB** becomes:

**……… (7)**

And from (2)   
 **……… (8)**

Substituting (7) and (8) into (4) we get

It shows that A and B are identical when at rest. The difference in mass depends upon the relative speed (v).

In example above the both A and B are moving in S. In order to obtain a formula that gives the mass m of a body measured while in motion in terms of its mass m0 when measured at rest, we need only consider a similar example in which VA and VB’ are very small as compared with v. In this case an observer in S will see B approach A with the velocity v, make a glancing collision (since VB’˂˂ v) and then continue on. In S mA= m0 and mB= m

***Experimental verification****:* The first experimental verification of variation of mass was found by **Bucherer** in his study of e**/m** of electron. The ratio of **e/m** of **electron** was **found smaller** **for fast moving** electron than for slow one.

Numerical problems:

1. For what value of v/c (say α) will the relativistic mass of a particle exceed its rest mass by a given fraction *f?*
2. A charged particle shows an acceleration of 4.1x10 12 cm/sec2 under an electric field at low speed. Compute the acceleration of the particle under the same field when the speed has reached a value 2.881x1010 cm/sec2. The **speed** of light is 3.0x1010 cm/sec.
3. The rest mass of a proton is 1.67x10-27 kg. At what speed will its rest mass be double its rest mass.
4. What is the length of a meter stick moving parallel to its length when its mass is 1.5 times of its rest mass?